SYNOPSIS OF RESEARCH PROJECT

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8.	**Title of Research Project:**		**A BOON TECHNOLOGY FOR FOLIAR NUTRITION TO ENHANCE PRODUCTIVITY OF SUMMER SESAME**

9. Introduction

Indian agricultural economy, oilseed crops play the second major role, alongside food seeds, in terms of area and production. The Indian climate is ideal for growing oilseed crops, so large varieties of oilseeds are grown here. Among the oilseed crops, sesame (*Sesamum indicum* L.) is well known and is one of the oldest crops in the World. The word sesame is from Latin *Sesamum* and Greek *Sesamon*. Most wild species of genus Sesamum are native to Sub-Saharan Africa and it belong to the family Pedaliaceae. The cultivated form of sesame is *Sesamum indicum* originated in India. Due to its high nutritional, medicinal, cosmetic and cooking qualities, it is known as **'the queen of oils'**. Sesame oil's main fatty acids are oleic and linoleic acids, which provide many nutritional and health benefits for humans. Sesame seeds also contain sesamine and sesamolin. Sesamolin upon hydrolysis yields sesmol, which has pronounced antioxidative activity which is an attribute for prolonged longer shelf life. By virtue of nutritional qualities, useful fatty acids and minerals, sesame is rightly called as **"seeds of immortality".** Sesame is cultivated worldwide on 12.84 million hectares, yielding 6.74 million tonnes, with an average

productivity of 525 kg per hectare. (FAOSTAT 2023).

The total area in India under sesame cultivation is 19.47 lakh ha and production is 8.66 lakh tones (Anon., 2022a) under major growing states of Gujarat, West Bengal, Rajasthan, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Karnataka and Maharashtra. Gujarat is one of the important oilseed growing states in the country, particularly for groundnut and sesame. The cultivated area of sesame in Gujarat is about 2.588 lakh ha with production of 1.225 lakh tonnes with average productivity of 473.43 kg/ha (Anon., 2022b).under major growing districts of Rajkot, Amreli, Bhavnagar, Bhuj, Jamnagar, Junagadh and Surendra nagar.

The historic origin of sesame was favored by its ability to grow in areas that do not support the growth of other crops. Sesame is a short day and short duration plant, which can be grown in all seasons of the year and fits well into various cropping systems. It is also a tough crop that needs little farming support, it grows in drought conditions, in high heat, with residual moisture in soil after monsoons or even when rains fail or when rains are excessive. It is a crop that could be grown by subsistence farmers at the edge of deserts, where no other crop can grow, so it has been called a survivor crop. Sesame is one of the drought tolerant crop, however it is sensitive to drought at germination and seedling stages. Now sesame cultivation is gaining popularity as a summer irrigated crop in the many parts of the country due to less infestation of pests and diseases as well as higher yield and monetary returns. The productivity of sesame under summer season is two times more than *Kharif* season.

The ability of plant leaves to absorb water and nutrients was recognized approximately three centuries ago. Foliar nutrition reduces the amount of fertilizer thereby reducing the fertilizer loss and also economizing crop production. Crop nutrition through foliar feeding at particular stage may improve the crop growth and seed yield without involving root absorption at critical stages (Latha and Nadanasababady, 2003).

The effectiveness of foliar applied nutrients is determined by the type of formulation and the time of application. Yield increase to an extent of 5-10 per cent (Sonawane *et al*., 2010) can be achieved by using the right product at the right time. Foliar nutrition is 8-10 times more effective than soil application. Foliar spray stimulates an increase in chlorophyll production, cellular activity and respiration. It also triggers a plant response to increased water and nutrient uptake from the soil (Veeramani *et al*., 2012).

The fertilizers contain different ratios of N, P and K which are highly water soluble and so amenable for foliar nutrition. The greater advantage in supplying the N, P and K as foliar spray was observed in many oil seed crops. In this direction foliar fertilization with major nutrients through water soluble fertilizers on oilseed crops like sesame was studied. Nitrogen is the basic constituent of all proteins and chlorophyll it helps in the vegetative growth of the plants by increasing cell division and cell elongation. Phosphorus is usually associated with increased root density and proliferation, which aid in extensive and supply of nutrients and water to growing plant. It brings early maturity of crops, drought resistance and improve seed formation. Potassium in photosynthesis, carbohydrate transport, water regulation and protein synthesis. It is suggested that foliar application of potassium during fruit growth helps in increased yield and quality. It is also help in improving drought and disease resistance.

Drones are unmanned aerial vehicle systems (UAVs) that are operated remotely and used to spray agrochemicals using an automated preprogrammed GPS system. (Pathak *et al.,* 2020). Recently, reducing the need for manual labour in potentially hazardous tasks, such as handling and applying fertilizers, drones contribute to the overall safety of agricultural operations. This technology also reduces farmers' exposure to chemicals and minimizes the risks associated with operating heavy machinery in challenging field conditions. The integration of drones into fertilizer application systems is a significant step towards sustainable agriculture. By precisely targeting fertilizer application, farmers can optimize nutrient management, reduce fertilizer runoff, and minimize the environmental impact on surrounding ecosystems. This targeted approach contributes to better soil health, water quality, and overall ecosystem balance. However, soil application is still seen as essential and cannot be fully replaced by foliar methods. Combining soil and foliar nutrient applications may be a more effective approach to meet crop nutrient needs. (Dayana *et al.* 2022).

10. Practical Utility of the Research Project

Research on foliar nutrition using drones in summer sesame indicates significant practical utilities, including increased yield and nutrient uptake, increased nutrient use efficiency, substantial time and labor savings, and enhanced application efficiency and sustainability compared to manual methods.

Foliar sprays can rapidly correct visible and sub-clinical nutrient deficiencies,

when high temperatures & moisture stress restrict root nutrient uptake during the summer season leading to better plant health. Foliar sprays use smaller quantities than soil broadcasting. Less wastage and reduced labor compared to manual spraying or soil application. Higher benefit-to-cost ratio for farmers, especially small holders. Drone is Useful on uneven or large sesame fields where ground sprayers struggle. Large areas can be sprayed in minutes versus hours with manual/tractor sprayers. Saves time and labor during peak summer workloads. Drones can deliver uniform foliar sprays across the canopy. Reduces skips and over-laps common with ground sprayers. Foliar spray can Increase seed yield, oil content, seed quality traits for Better market returns for farmers.

The experiment was conducted with the objective of standardizing nutrient concentration and selection of suitable type drone with nozzle for spraying nutrient and crop booster to improve the yield summer sesame var. GT-5 and the hence the foliar application of nutrients and crop boosters is to be studied for its feasibility and applicability.

11. Objectives

- ✓ To study the effect of water soluble fertilizer on growth, yield and of quality summer sesame.
- ✓ To study the effect of spraying using drone over conventional sprayers on growth, yield and quality of summer sesame.
- ✓ To work out the economics of different treatments.

12. Review of Literature

The literature on "A boon technology for foliar nutrition to enhance productivity of summer sesame" carried out on various aspects of present investigation was reviewed under following heads.

12.1 Effect of soil application of NPK fertilizers

12.1.1 Effect of soil application of NPK fertilizers on growth

Kene *et al.* (1991) reported the highest dry matter yield, seed yield and oil content of sesame cv. Phule-1 with the application of 40 kg N + 40 kg P_2O_5+ 25 kg K_2O/ha (2.59 and 0.30 t/ha and 50.26%, respectively) during *kharif* season at Nagpur (Maharashtra).

Mian *et al.* (2011) conducted a field experiment at Regional Agricultural Research Station, Bangladesh, reported that growth parameters *viz.*, plant height (99

and 93 cm) and the number of branches per plant (4.28 and 3.99) were highest with 120 kg P/ha and statistically on par with 90 and 60 kg P/ha.

Hafiz and El-Bramawy (2012) concluded that plant height (151.67, 162.87 and 170.59 cm) and the number of branches per plant (8.57, 9.07 and 9.65) were highest with 76 kg/ha + phosphorin compared to the subsequent lower doses (57 and 76 kg/ha) as well as the immediate higher dose (95 kg/ha) in sandy soils of Ismalia, Egypt.

Mahajan *et al*. (2013) reported that the application of 100% RDN (50 kg N/ha) + castor cake (2.5 t/ ha) increased the plant height (147 cm) and the number of branches per plant significantly over other treatments. However, it was at par with 100% RDN (50 kg N/ha) + FYM and vermicompost (2.5 t/ha) at Mamurabad Farm of Oilseed Research Station, Jalgaon, Maharashtra.

Thanki *et al*. (2014) from their experiment on clayey soils of Junagadh Agricultural University, Gujarat concluded that plant height (71.07 cm) and the number of branches per plant (3.31) were highest with 75:50:50 kg $N:P_2O_5:K_2O$/ha.

Ajibola *et al*. (2015) stated that increased levels of nitrogen (0, 60, 80 and 100 kg/ha) increased the plant height (144.06 cm), the number of branches per plant (8) but the increase was significant only up to 80 kg/ha on sandy soils of Research Farm of Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Ali *et al.* (2017) reported that sesame fertilized with a higher rate of N (110 kg/ha) took significantly more number of days to 50% flowering (56.1 days) and days to maturity (110.6) compared to 30 and 70 kg N/ha at ARF, UA, Peshawar, Pakistan.

Jamdhade *et al*. (2017) conducted a field experiment on the influence of irrigation regimes and nitrogen levels on growth, yield and economics of summer sesame and found that the highest plant height (84.68 cm), dry matter accumulation per plant (19.25 g), branches per plant (4.30) and the number of leaves per plant (84.68) with the application of 60 kg N/ha on clay loamy soil of Agronomy Farm, PDKV, Akola.

Sangama *et al*. (2022) result revealed that the combination of 75% Recommended Dose of Fertilizers + 25% Farmyard Manure resulted *in the highest growth attributes, including number of capsule per plant (51.20*), longer capsule (2.63 cm), number of seed per capsule (71.33) in Nagaland.

Shweta *et al.* (2023) reported that application of N at 30 kg/ha enhanced the activity of CO_2 fixing enzymes, rate of photosynthesis, dry matter accumulation and partitioning of assimilates to sink, ultimately leading to higher seed yield in sesame.

Golan *et al*. (2022) observed that higher rate of N application resulted in reduced photosynthetic rate, stomatal conductance and leaf water potential in sesame. The results on growth parameters confirmed the sufficiency of 31 kg N/ha for sesame in Southern Laterites.

Ahmad *et al.* (2022) opined that increase in chlorophyll content could also be the result of better assimilation of nutrients especially N.

12.1.2 Effect of soil application of NPK fertilizers on yield of summer sesame

Ghosh and Patra (1994) reported the maximum seed yield of sesame cv. Tilottama with the application of 96 kg N + 18 kg P_2O_5+ 52 kg K_2O/ha in lateritic sandy loam soils of Sriniketan (West Bengal).

Abdel-Sabour and El-Seoud (1996) reported maximum seed yield of sesame cv. B-67 with the application of 75% NPK + 10 t FYM/ ha in sandy loam soils of West Bengal (India).

Ojikpong *et al*. (2009) recorded the highest number of capsules per plant (54.9) and seed yield (477.5 kg/ ha) with 150 kg NPK/ ha (15:15:15 NPK-fertilizer) compared to subsequent lower levels.

Jooyban and Moosavi (2012) in their studies on the effect of different irrigation, N and super absorbent levels on yield and yield components of sesame reported the highest seed yield (580.86 kg/ha) and straw yield (4030.25 kg/ha) with the application of 200 kg N/ ha over other treatments at Khosf Region, Birjand, Iran.

Damdar *et al.* (2014) studied the effect of irrigation and nitrogen levels on yield and water use efficiency of summer sesame in clay loamy soils at Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The results of the trial revealed that the number of capsules per plant (44.72) and test weight (3.02 g) was highest with 90 kg N/ha.

An experiment was undertaken by Patel and Raj (2017) during summer season of 2016 at College Farm, Navsari Agricultural University, Navsari, to study the response of summer sesame to nitrogen, phosphorus and biofertilizers. They concluded that significantly higher seed yield, stover yield and nutrient uptake (N, P and K) by seed and haulm recorded with application of 75 kg N/ha and 37.5 kg P/ha which was at par with 50 kg/ha and 25 kg/ha.

A field experiment was conducted during summer at Navsari Agricultural University, Navsari to study the effect of spacing and nutrient management on summer sesame by Patel *et al*. (2018) and they revealed that maximum plant height,

number of branches per plant, dry matter production per plant, number of capsules per plant, number of seeds per capsule, seed yield and straw yield, were recorded with the application of 100 per cent RDF, i.e. (50-25-0 kg N-P_2O_5-K_2O/ha).

Padasalagi *et al*. (2024) concluded based on an experiment at GKVK, UAS, Bengaluru, that application of the recommended dose of fertilizers (RDF) in sesame combined with 30 kg of sulphur and 5 kg of borax per hectare resulted in the highest seed yield and stalk yield. The higher yields were attributed to increased nutrient uptake nitrogen (40.23 kg/ha), phosphorus (15.01 kg/ha), potassium (45.23 kg/ha), sulphur (13 kg/ha), and boron (162.4 ppm), which enhanced both seed and stalk growth.

Sahu *et al*. (2024) revealed that application of 30:15:15 NPK kg/ha resulted in the greatest number of capsules per plant (37.6), seeds per capsule (48.1), higher seed yield (591.9 kg/ ha), haulm yield (1786.7 kg/ha) and harvest index (0.24) in sesame.

12.1.3 Effect of soil application of NPK fertilizers on quality of summer sesame

Malik *et al.* (2003) stated that the application of 80 kg N/ ha resulted in the highest oil content (45.88 %) at Agronomic Research Farm, Faisalabad, Pakistan.

Vaghani *et al*. (2010) obtained maximum oil content (50.6 and 50.3 %) with 100 kg N and 80 kg K_2O/ha at Junagadh Agricultural University, Amreli, Gujarat.

Bhosale *et al*. (2011) conducted an experiment on medium clay soils at Junagadh Agricultural University, Junagadh, Gujarat and observed the highest protein content (27.82 %) with the application of potash @ 50 kg/ha.

Ali and Ahmed (2012) recorded that oil content was highest with 90 kg / ha whereas oil yield (439 kg/ha) increased with an increase in N level up to150 kg N/ha in sandy soils of Experimental Farm, Sebha University, Libia.

Tripathy and Bastia (2012) reported the highest oil yield (437 kg/ha) with 50% (30:6.6:12) NPK/ha+ FYM 5 t/ha at Central Research Station, Orissa University of Agriculture and Technology, Bhubaneswar.

Kumara *et al*. (2014) obtained the highest protein content (25.42 %) with 40:25:25 kg N:P_2O_5:K_2O/ha at Agricultural Research Station, Dharwad, Karnataka.

Lakhran *et al*. (2015) conducted an experiment at Anand Agricultural University, Gujarat and reported the highest oil content (48.48 %) and oil yield (574.1 kg/ha) with 75 % RDF + 5 t FYM/ha + Bio-fertilizer.

Jose *et al*. (2022) observed that application of 50:25:30 NPK kg/ha resulted in higher P, Fe and Zn content in the sesame seeds.

Priya *et al*. (2022) revealed that application of 40:20:20 NPK kg/ha resulted higher oil content (52.0%) in sesame compared to control (51.3%).

Ishfaq *et al*. (2023) observed that application of optimum dose of fertilizers improved the nutritional quality by enhancing the content of mineral nutrients (K, Ca, Mg, Zn and Fe) in the seeds of food crops.

12.2 Effect of foliar application of NPK fertilizers

12.2.1 Effect of foliar application of NPK fertilizers on growth of summer sesame

Aruna *et al*. (2001) reported that foliar application of 2% DAP + 0.5% $ZnSO_4$+ 0.5% boric acid resulted in the highest dry matter accumulation and nutrient (N, P, K and B) uptake by the groundnut crop.

Ramesh and Thirumurugan (2001) reported that foliar application of DAP at 2% and KCL at 1% along with benzyl adenine at 25 ppm recorded significantly higher plant height of soybean.

A field experiment was conducted during *kharif* 2013 to study foliar nutrition in groundnut (*Arachis hypogea* L.) at Main Agricultural Research Station, Dharwad under rainfed situation by Vinod and Salakinkop (2017). They concluded that plant height (23.94 cm), number of branches/plant (7.82), chlorophyll content (43.58), leaf area (8.90 m^2 per plant), total dry matter production (40.22 g per plant) were higher in foliar spray of 2.0% urea + DAP + MOP combination in groundnut at 45 DAS followed by foliar spray of 19:19:19 N: P_2O_5:K_2O compared to control (No spray).

A field experiment was conducted at University of Agricultural Sciences, Dharwad on medium black soil during *kharif* season of 2015 to study the effect of foliar feeding of water soluble fertilizers on growth and economics of soybean in a vertisol by Chetana and Math (2018). They observed that significantly higher growth parameters in soybean, like number of branches per plant (5.20), total dry matter production (60.35 g per plant), higher B:C ratio by the application of two foliar sprays of (1%), 19:19:19. Which was followed by urea (1%), KNO_3 (2%) and one spray of

19:19:19 (1%) at 60 DAS compared to control.

Samui *et al.* (2022) found that plant height, dry matter increased significantly with foliar spray of nano-urea @ 4 ml/L in addition to 100% RDN followed by 75% RDN + foliar spray of nano-urea @ ml/L at Agriculture University Odisha.

Pravalika *et al*. (2023) found that the result, sulphur 30 kg/ha + zinc 0.5% (T7), plant height (95.1 cm), plant dry weight (20.48 g per plant), number of capsules per plant (52.9), high number of seeds per capsules (63.2), test weight (3.26 g), seed yield (1.41 t/ha), stover yield (6.44 t/ha), Harvest index (17.92%).

Nano DAP is an effective source of nitrogen (8.0 % N w/v) and phosphorus (16.0 % P_2O_5 w/v). Nano DAP with an advantage in terms of surface area to volume due to the particles size less than 100 nano meter can readily enter the stomata and timely availability at critical stages for nutrition. Bio-polymers and other excipients are used to functionalize the nitrogen and phosphorus nanoclusters in nano DAP. Nano-fertilizers enhance nutrient use efficiency due to their better penetration ability and translocation within plant parts (Kopittke *et al*., 2019).

12.2.2 Effect of foliar application of NPK fertilizers on yield of summer sesame

A Field experiment on sandy clay loam was conducted during summer season of 2017 to investigate the effect of seed pelleting and foliar nutrition on yield and productivity of summer irrigated sesame (*Sesamum indicum* L.) at Tamil Nadu Agricultural University, Coimbatore and observed that foliar application of i.e. Urea (1%), DAP (1%), 19:19:19 (NPK) (1%), $MnSO_4$(0.5%) and MAP (0.5%) sprayed at 30 and 45 DAS recorded maximum plant height (127.4 cm) DMP (3856 kg/ha), number of branches (9.8), number of capsules per plant (153.2), seeds per capsule (58.4), thousand seed weight (3.12 g) and seed yield (719 kg/ha) in sesame (Teresa *et al*., 2017).

A field experiment was conducted during *kharif* 2013 to evaluate the effect of foliar nutrition in groundnut (*Arachis hypogea* L.) at Main Agricultural Research Station, Dharwad under rainfed situation by Vinod and Salakinkop (2017) revealed that pod yield (3746 kg/ha), kernel yield (2905 kg/ha), haulm yield (4253 kg/ha) and harvest index (0.36) were significantly higher in foliar spray of 2.0% Urea + DAP + MOP combination at 45 DAS followed by foliar spray of 19:19:19 $N:P_2O_5:K_2O$ compared to control (No spray).

A field experiment was conducted at Department of Crop Physiology, C.S. Azad University of Agriculture and Technology, Kanpur, to study the effect of foliar application of thiourea and potassium nitrate on physiological growth at different stages of sesame. Result revealed that yield attributes *viz*, number of capsules per plant, number of seeds per capsule, test weight (g), seed yield, biological yield per plant were significantly higher in crop under foliar application of thiourea and KNO_3 over thiourea and control (Kumar *et al*., 2018).

An experiment was conducted by Mandeep *et al*. (2019) to study the effect of foliar application of nitrogen, phosphorus and sulphur on growth and yield of Gobhi Sarson (*Brassica napus* L.) during *Rabi* season 2017 at Experimental Farm, MGC, Shri Fatehgarh Sahib, Punjab. They concluded that growth and yield attributing parameters were maximum with the foliar application of 2% DAP + 2% Urea application followed by 0.5% DAP foliar application + 0.5% sulphur application and 0.5% urea + 0.5% sulphur spray at 60, 90 DAS and at harvest stage.

Swain *et al*. (2020) studied the effect of foliar application of nutrients on growth and yield of sesame (*Sesamum indicum* L.) and noted that the yield components and yield have manifested better expression under the application of urea (0.4%) + KCL (1.0%) followed by the application of urea (0.4%) + KNO_3 (1.0%). The mean yield under urea (0.4%) + KCL (1.0%), urea (0.4%) + KNO_3 (1.0%) and control are 7.85, 7.81 and 6.21 quintal/ha respectively.

Effect of spacing and foliar application of zinc on growth, yield and economics of sesame during *kharif* 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The results revealed that the 40cm×10cm + $ZnSO_4$ (0.75%) recorded significantly higher plant height (125.73 cm), highest plant dry weight (15.57 g), number of capsules per plant (54.60), number of seed per plant (60.50) and seed yield (1.20 t/ ha) and stover yield (2.57 t/ha) (Haritha *et al*., 2022).

To assessing effect of foliar application of nutrients and growth regulators on sesame in the old alluvial zone of West Bengal. Hoque and Sarkar (2022) conducted a field experiment at Malda Krishi Vigyan Kendra, UBKV, Malda, West Bengal. The results revealed that significantly higher values of number of capsules per plant (47.61), number of seeds per capsule (67.41), grain yield (1174 kg/ ha) were recorded with the foliar application of $N:P_2O_5:K_2O$ 19:19:19 at 0.5% followed by $N:P_2O_5:K_2O$ 10:26:26 at 2%. While higher value of test weight (4.32) recorded with treatment

$N:P_2O_5:K_2O$ (10:26:26) at 2%.

Ruchitha *et al.* (2023) showed that viz: plant height (130.82 cm), number of branches per plant (4.89), dry weight (13.41 g per plant), crop growth rate (10.93 gm^2 /day) at 40-60 DAS interval, relative growth rate (0.106g/day) at 20-40 DAS interval, number of capsules per plant (28.25), number of seeds per capsule (46.88), test weight (2.80), seed yield (1235.01 kg/ha), stalk yield (2195.21 kg/ha), harvest index (36.00%) were recorded significantly higher with the application of sulphur 25 kg/ha + zinc 0.5% foliar spray. Higher gross returns (98801 INR/ha), net return (69555 INR/ha), and benefit-cost ratio (2.37) were also obtained with the application of sulphur 25 kg/ha + zinc 0.5% foliar spray.

12.2.3 Effect of foliar application of NPK fertilizers on quality of summer sesame

Brighenti and Castro (2008) conducted an experiment in Brazil to know the effect of boron foliar spray on the yield of sunflower. The treatments consist of two sources of boron i.e. boric acid (17 % B) and sodium borate (20.5 % B) applied with herbicides. Higher oil content (40.6%) was seen with boric acid treatment which was on par with sodium borate application.

A field study was carried out to assess the effects of micronutrient foliar application on quantitative traits and seed oil content of safflower in 2008 to 2009 growing season at Research Farm of Faculty of Agriculture, Zabol University, Iran, Galavi *et al.* (2012) reported that the maximum oil percentage was achieved from foliar application of Fe + B.

Verma, *et al.* (2012) result revealed that the application of 50% nitrogen (N) through farm yard manure (FYM) and remaining 50% through inorganic fertilizers resulted found the higher oil content treatment, oil content in the seeds ranged from 47.24 to 49.60%.

Prakash *et al.* (2013) conducted an experiment in Tamil Nadu to know the effect of foliar spray of micronutrients on sesame. Application of 0.1 % of borax recorded the higher oil content (49.3%), protein content (32.12%) and oil yield (523.47 kg/ha) as compared to control and other treatments.

A field experiment was conducted by Seervi *et al.* (2018) at the Department of Agronomy, Bhagwant University to study the effect of micronutrients applied as a foliar spray on yield, yield attributes and oil content of sesame. They noted that the highest yield (1410 kg/ ha) and oil content (50.2%) with the foliar application of a mixture of B, Zn, Mo, Cu, Fe, Mn and Co (100 + 100 + 50 + 100 + 100 +100 + 50)

ppm whereas control recorded significantly lower yield parameters and oil contents.

12.2.4 Combine effect of soil and foliar application

Mahajan *et al.* (2016) found that highest plant height (133 cm), number of branches per plant and yield attributes *viz.*, number of capsules per plant (47.18), number of seeds per capsule (21.82), test weight (2.81 g), seed yield (723 kg/ha) and oil yield (359 kg/ha) with soil application of RDF + foliar spray of 2 % urea at flowering and capsule formation stages over soil application of RDF alone.

Application of 125 % RDF along with foliar application 19:19:19 @ 1.0 % at early budding stage followed by 1.0 % KNO_3 at early capsule formation stage on sesame was investigated by Deepthi *et al.* (2018) studied the effect of soil application of varied levels of NPK and foliar nutrition on yield and yield attributes of sesame during *Rabi*, 2016-17 on sandy loam soils of Agricultural College Farm, Naira, they observed that application of 125 RDF and foliar application of 1% (19:19:19) + 1% KNO_3 resulted significantly higher values of number of seeds per capsule, number of capsules per plant, highest capsule length, test weight, seed yield (923 kg/ ha) and stalk yield (2095 kg/ha).

Foliar nutrition on productivity of groundnut crop were investigated by Shwetha *et al*. (2018) during summer 2013-14 at Agricultural Research Station, Kawadimatti, Karnataka. They observed that 1% of 19:19:19 along with recommended dose of fertilizer recorded higher pod yield which was on par with 3% Biomax spray, 1% multinutrient spray and 10% cow urine spray.

12.3 Effect of spraying using drone over conventional sprayers

Dayana *et al*. (2021) an field experiment at Tamil Nadu Agricultural University, Tiruchirappalli during summer 2021 to study the effect of foliar application of nutrients using agricultural drone on growth, yield and quality of green gram. Results revealed that application of 2% TNAU pulse wonder with spray fluid of 50 litters/ha significantly recorded taller plants (49.1 cm), higher dry matter production (2311 kg/ha), more number of flower per plant (54.6), number of pods per plant (39.2), higher grain yield (747 kg/ ha), haulm yield (1684 kg/ ha), grain protein (23.5%) and grain carbohydrate (57.9%) compared to manual spray and control. Hence, it is concluded that drone spray of 2% TNAU pulse wonder with spray fluid of 50 litres/ha at peak flowering stage could be recommended to improve the yield and quality of green gram.

Kaniska *et al*. (2022) conducted field experiment at the ARS, Bhavanisagar, TNAU during summer season of the year 2022 to study the impact of drone spraying of nutrients on growth and yield of maize. Application of NPK 19:19:19 along with liquid micronutrient, humic acid at two intervals viz., 50% tasselling and cob filling stage. Foliar application of nutrients through drones had a significant influence on the growth and yield of maize. Fuel-operated drone with an atomizer nozzle @ 30 lit/acre spray fluid recorded the maximum biometric and yield attributes than other treatments. Improved biometric attributes like plant height of 261.2 cm and 270.32 cm, LAI of 4.14 and 5.15, and DMP of 12354 kg/ha and 18564 kg/ha at 60 DAS and 90 DAS respectively was recorded with drone spray. It also resulted in a higher grain and stover yield of maize 7195 kg/ha and 10942 kg/ha respectively than hand sprayer.

Nandhini *et al*. (2022) conducted experiment at Northern block (N block) of Tamil Nadu Agricultural Research Station (ARS), Bhavanisagar, during summer season of the 2021 to study Inter comparison of drone and conventional spraying nutrients on crop growth and yield in black gram. The results revealed that fuel operated drone spray of 2% pulse wonder with spray fluid of 75 L/ ha using atomizer nozzle recorded the highest growth and yield attributes values and registered the highest grain and haulm yield of 784 and 1525 kg/ha. Concluded that fuel operated drone spray of 2% pulse wonder using the atomizer nozzle with spray fluid of 75 L/ ha is adopted to enhance the growth and grain yield of black gram.

12.4 Effect on economics of summer sesame

Application of 100% recommended dose of fertilizers was more remunerative with higher B:C ratio (2.26) followed by 100% RDF + FYM 2.5 t/ha (2.10) due to lower cost of cultivation as reported by Chaurasia *et al.* (2009).

Application of 50% RDF + 5t FYM/ha recorded highest net returns (₹ 4659/ ha) and B:C ratio (0.56) over 100 % RDF and 5 t FYM/ha alone in summer sesame on sandy loam soils of Odisha (Tripathy and Bastia, 2012).

Ghosh *et al*. (2013) reported that significantly higher net returns and gross returns were obtained with application of 50 % RDF + 50 % N through FYM + *Azospirillum* over 100% RDF in summer sesame on sandy loam soils of Sriniketan, West Bengal.

Krishnaveni *et al*. (2024) found that application of 40:20:20 NPK kg/ha resulted in higher gross return (57,959 ₹/ha), net return (34,341 ₹/ha) and B:C ratio (1.45) in sesame.

13. Materials and Methods

13.1 Location : Instructional Farm, JAU, Junagadh

13.2 Year and season of experiment : *Summer*- 2026 and 2027

13.3 Experimental design : Large Plot Technique

13.4 No. of treatments : Eight (8)

13.5 No. of sampling : Five (5)

13.6 Spacing : 30 cm x 10 cm

13.7 Crop and variety : Sesame, GT-5

13.8 Seed rate **:** 3.75 kg/ha

13.9 Plot size : 30 m x 3.0 m

13.10 Recommended dose of fertilizer : 50-25-40 kg N-P_2O_5-K_2O/ha

13.11 Treatment details :

T_1 : Absolute control

T_2 : RDF (50-25-40 kg N-P_2O_5-K_2O/ha)

T_3 : Foliar application of 1 % 19-19-19 WSF at 30, 45, & 60 DAS using a Knapsack sprayer (300 L/ha)

T_4 : Foliar application of 1 % 13-00-45 WSF at 30, 45, & 60 DAS using a Knapsack sprayer (300 L/ha)

T_5 : Foliar application of 15 % 19-19-19 WSF at 30, 45, & 60 DAS using a Drone (40 L/ha)

T_6 : Foliar application of 15 % 13-00-45 WSF at 30, 45, & 60 DAS using a Drone (40 L/ha)

T_7 : Foliar application of Nano DAP (4 ml/lit.) at 30, 45, & 60 DAS using a Knapsack sprayer (300 L/ha)

T_8 : Foliar application of Nano DAP (4 ml/lit.) at 30, 45, & 60 DAS using a Drone (40 L/ha)

Note: 75% RDF as basal application to T_3 to T_8.

13.12 Sprayer details

Battery Operated Drone Sprayer

Dimension (mm)	:	1520 x 1520 x 590
Nozzle type	:	Flood Jet
Tank Capacity	:	10 L
Battery capacity	:	22000 mAh
Spraying width (m)	:	3.5 m
Flying height (m)	:	0.75 to 1.0 m
No. of nozzles	:	4

Knapsack Sprayer

Dimension (cm)	:	41.9 x 17.8 x 53.3
Nozzle type	:	Hollow cone
Tank Capacity	:	15 L
Spraying width (m)	:	0.75 to 1.0 m
Flying height (m)	:	20 to 30 cm above the crop canopy
No. of nozzles	:	1

13.13 Observations to be recorded

- **Growth parameters**

1. Plant population 20 DAS and at harvest
2. Plant height (cm) at 30, 60 DAS and at harvest
3. Number of branches per plant
4. Chlorophyll content (SPAD value) at before and after spray
5. Dry matter accumulation per plant (gm) at harvest

- **Yield and yield attributes**

1. Number of capsules per plant
2. Number of seeds per capsules
3. Test weight (1000 seed weight)
4. Seed yield (kg/ha)
5. Stalk yield (kg/ha)
6. Harvest index (%)

- **Energy balance analysis**

1. Input-output energy
2. Energy use efficiency
3. Energy productivity

4. Sprayer work efficiency

❖ **Quality parameters**

1. Oil content (%)
2. Oil yield (kg/ha)

❖ **Chemical studies**

1. Plant analysis : N, P and K content (%) and uptake (kg/ha) by grain and stalk after harvest

Nutrient content in crop will be determined by the following procedure

Nutrients	Method	Reference
Nitrogen	Micro kjeldahl's method	Kanwar and Chopra (1967)
Phosphorus	Vando-molybdo phosphoric acid yellow color method	Jackson (1974)
Potassium	Flame photometer method	Jackson (1974)

Nutrient uptake will be calculated by using following formula

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient concentration (\%) x Biological yield (kg/ha)}}{100}$$

2. Soil analysis : Available N, P and K content in soil before sowing and after harvest of crop.

Nutrient content in soil will be determined by the following procedure

Nutrients	Method	Reference
Available Nitrogen	Alkaline permanganate method	Subbiah and Asija (1956)
Available Phosphorus	Olsen's method	Olsen *et al*. (1954)
Available Potassium	Flame photometric method	Jackson (1974)

13.14 Economics

1. Cost of cultivation (₹/ha)

The expenses incurred for all the cultivation operations from preparatory tillage to harvesting including the cost of inputs *viz*., seeds, fertilizers, herbicides, pesticides, *etc*. applied to treatments will be calculated on the basis of prevailing local charges.

2. Gross return (₹/ha)

The gross realization in terms of rupees per hectare will be worked out taking into consideration the seed and leaf yields from each treatment and local market prices.

3. Net return (₹/ha)

Net returns of each treatment will be calculated by deducting the total cost of cultivation from the gross returns.

4. Benefit cost ratio (B:C ratio)

The benefit cost ratio will be calculated with the help of following formula

$$\text{B: C ratio} = \frac{\text{Gross return (₹/ha)}}{\text{Total cost of cultivation (₹/ha)}}$$

14. Statistical Analysis

The data will be subjected to statistical analysis by adopting appropriate analysis of variance as described by Gomez and Gomez (1984). Wherever the F values found significant at 5 per cent level of probability, the critical difference (CD) values will be computed for making comparison among the treatment means. In order to establish interrelationship between various components, coefficients of correlation and regression equations will be computed as described by Panse and Sukhatme (1985).

15. References

Abdel-Sabour, M. F. and El-Seoud, M. A. (1996). Effects of organic-waste compost addition on sesame growth, yield and chemical composition. Agriculture, *Ecosystems & Environment*, **60**(2-3): 157-164.

Ahmad, S., Wang, G.Y., Muhammad, I., Chi, Y.X., Zeeshan, M., Nasar, J., and Zhou, X.B. (2022). Interactive effects of melatonin and nitrogen improve drought tolerance of maize seedlings by regulating growth and physiochemical attributes. *Antioxidants* **11**(2): 359-367

Ajibola, A. T., Modupeola T. O., Olatunji, O. O. and Akinleye, O. C. (2015). Effects of type and rate of organic and mineral fertilizer application on the performance of sesame (*Sesamum indicum* L.) in the Southern Guinea Savanna of Nigeria. *Journal of Biological Chemical Research*, **32**(2): 1027-1035.

Ali, A., Khan, N., Khan, R., Sohail, Z. U., Ali, M., Junaid, M., Awan, M. O. U., Ahmad, I., Khalil, A. U. R., Liaqat, A., Nawaz, F. and Shah, J. A. (2017). Growth of sesame (*Sesamum indicum* L.) as affected by nitrogen and sulfur under semiarid climate. *Pure and Applied Biology*, **6**(1): 40-46.

Ali, E. A. and Ahmed, S. Y. (2012). Influence of nitrogen rates and foliar spray by different concentration of copper on sesame seed and oil yields

as well as nitrogen use efficiency in sandy soils. Research *Journal of Agriculture and Biological Sciences*, **8**(2): 174-178.

Anonymous (2022a). Agricultural Statistics at a Glance. https://agricoop.gov.in / Documents/CWWGDATA/ Agricultural Statistics at a Glance 2022.pdf [Accessed 1st Feb 2024].

Anonymous (2022b). Directorate of Agriculture Gujarat of Government, Gandhinagar. https://dag.gujarat.gov.in [Accessed 1st Feb 2024].

Aruna, E., Rao, P. G. and Krishnamurthy, V. R. (2001). Effect of post-flowering nutrition on dry matter production and nutrient uptake in bold kernel type groundnut (*Arachis hypogaea*). *Research on Crops*, **2**(2): 134-136.

Bhosale, N. D., Dabhi, B. M., Gaikwad, V. P. and Agarwal, M. C. (2011). Influence of potash and sulphur levels on yield, quality and economics of sesamum (*Sesamum indicum* L.). *International Journal of Plant Sciences*, **6**(2): 335-337.

Brighenti, A. M. and Castro, C. (2008). Boron foliar application on sunflower (*Helianthus annus*. L.) associated with herbicides. *Scientific journal of Helianthus annuus* L. HELIA, **31**(48): 127-136.

Chaurasia, S. K., Jain, N. and Jain, N. (2009). Effect of integrated use of fertilizers, organic manures and micronutrients on productivity of sesame (*Sesamum indicum* L.). *Annual Agriculture Research New Series*, **30**(3&4): 91-94.

Chetana, B. and Math, K. K. (2018). Effect of foliar fertilization of water soluble fertilizers on growth and economics of soybean in a vertisol. *Journal of Pharmacognosy and Phytochemistry*, **7**(2): 2391-2393.

Damdar R. R., Bhale, V. M., Wanjare, P. G. and Deshmukh, K. M. (2014). Effect of irrigation and nitrogen levels on yield and water use efficiency of summer sesame. *American Eurasian Journal of Agricultural and Environmental Sciences*, **14**(9): 807-810.

Dayana, K., Ramesh, T., Avudaithai, S. Paul, S., Sebastian and Rathika, S. (2021). Foliar application of nutrients using agricultural drone on yield and quality of green gram (*Vigna radiata* L.). *The Pharma Innovation Journal SP*, **10**(12): 69-72.

Dayana, K., Ramesh, T., Avudaithai, S., Sebastian, S. P., Rathika, S. (2022). Feasibility of using drone for foliar spraying of nutrients in irrigated green gram (*Vigna radiata* L.). *Ecology, Environment and Conservation*, **28:** 589-594.

Deepthi, C. H., Ramana, A. V. Upendra Rao, A. and Guru Murthy, P. (2018). Effect of soil and foliar applied fertilizers on yield attributes and yield of *Rabi* sesame. *Journal of Pharmacognosy and Phytochemistry*, **7**(4): 2824-2827.

FAOSTAT (2023). Food and Agriculture Organization of the United Nations (FAO). http://www.fao.org/faostat/en/data/OC.

Galavi, M. Ramroudi, M. and Tavassoli, A. (2012). Effect of micronutrients foliar application on yield and seed oil content of safflower (*Carthamus tinctorius*). *African Journal of Agricultural Research*, **7**(3): 482-486.

Ghosh, A. K., Duary, B and Ghosh, D.C. (2013). Nutrient management in summer sesame (*Sesamum indicum* L.) and its residual effect on black gram (*Vigna mungo* L.). *International Journal of Bio-resource and Stress Management*. **4**(4): 541-546.

Ghosh, D. C. and Patra, A. K. (1994). Effect of plant density and fertility levels on productivity and economics of summer sesame. (*Sesamum indicum*). *Indian Journal of Agronomy*, **39**(1): 71-75.

Golan, E., Peleg, Z., Tietel, Z. and Erel, R. (2022). Sesame response to nitrogen management under contrasting water availabilities. *Oil Crop Science* **7**(4): 166-173.

Gomez, K. A. and Gomez, A. A. (1984). Statistical Procedures for Agricultural Research (2nd Ed.), New York, John Willey and Sons.

Hafiz, S. I. and El-Bramawy, M.A.S. (2012). Response of sesame (*Sesamum indicum* L.) to phosphorus fertilization and spraying with potassium in newly reclaimed sandy soils. Basic Research Journal Agricultural Science. **1**(5): 117-123.

Haritha, G., Singh, R. and Thakur, I. (2022). Studies on growth and yield of sesame (*Sesamum indicum* L.) as influenced by spacing and foliar application of zinc. *The Pharma Innovation Journal*, **11**(3): 2366-2369.

Hoque, A. and Sarkar, L. (2022). Assessing effect foliar application of nutrients and growth regulators on sesame (*Sesamum indicum* L.) in the old alluvial zone of West Bengal. *The Pharma Innovation Journal*, **11**(12): 1344-1348.

Ishfaq, M., Wang, Y., Xu, J., Hassan, M.U., Yuan, H., Liu, L., He, B., Ejaz, I., White, P.J., Cakmak, I., and Chen, W.S. (2023). Improvement of nutritional

quality of food crops with fertilizer: a global meta-analysis. *Agronomy for Sustainable Development* **43**(6): 35-44.

Jackson, M. L. (1974). Soil chemical analysis. Prentice hall of Indian Pvt. Ltd., New Delhi, Pp. 327-350.

Jamdhade, K. Chorey, A., Bharti, T. and Bhale, V. M. (2017). Influence of irrigation regimes and nitrogen levels on growth, yield and economics of summer sesame. *International Journal of Current Microbiology and Applied Sciences*, **6**(3): 2389-2393.

Jooyban, Z. and Moosavi, S. G. (2012). Seed yield and some yield components of sesame as affected by irrigation interval and different levels of N fertilization and superabsorbent. *African Journal of Biotechnology*, **11**(49): 10944-10948.

Jose, S., Pavaya, R.P., Kumar, J.S., and Malav, J.K. (2022). Influence of different combinations of NPK and micronutrients on nutritional status and quality parameters of sesame under loamy sand of Gujarat. *Journal of Pharmaceutical Innovation*, **11**(11): 1846-1851.

Kaniska K., Jagadeeswaran, R., Kumaraperumal R., Ragunath, K.P., Balaji Kannan Muthumanickam, D. and Pazhanivelan, S. (2022). Impact of drone spraying of nutrients on growth and yield of maize crop. *International Journal of Environment and Climate Change* **12**(11): 274-282.

Kanwar, J. S. and Chopra, S. L. (1967). Analytical Agricultural Chemistry. Kalyani Publishers, New Delhi, Pp.518.

Kene, D. R., Mankar, B. T., Thakare, K. K. and Darange, O. G. (1991). Response of sesame to NPK fertilization and forms of phosphate. *PKV Research Journal*, **15**(2): 166-167.

Kopittke, P.M., Lombi, E., Wang, P., Schjoerring, J.K and Husted, S. (2019). Nano materials as fertilizers for improving plant mineral nutrition and environmental outcomes. *Environmental Science*. **6**(12): 3513-3524.

Krishnaveni, D., Ramesh, G., Ratnam, M., Latha, M. and Chandrasekhar, K. (2024). Yield and economics of rice fallow sesame (*Sesamum indicum* L.) as influenced by nutrient management practices. *International journal research in agronomy.* **7**(4): 521-523.

Kumar, A. Singh, S. N. and Khan, M. A. (2018). Effect of foliar application of thiourea and potassium nitrate on physiological growth at different stages of sesame (*Sesame indicum* L.). *Journal of Pharmacognosy and Phytochemistry*, **7**(2): 2156-2158.

Kumara, B. P., Chittapur, B. M., Hiremath, S. M. and Malligwad, L. H. (2014). Enhancing productivity of summer sesame (*Sesamum indicum*) on paddy fallows through optimization of fertilizer, planting geometry and genotypes. *Indian Journal Agricultural Sciences*, **84**(6): 720-724.

Lakhran, H., Sadhu, A. C. and Kumawat, S. (2015). Quality and yield potential of summer sesame (*Sesamum indicum* L.) as influenced by sowing time and nutrient management in middle Gujarat. *The Bioscan*, **10**(3): 1409-1411.

Latha, M. R. and Nadanasababady, T. (2003). Foliar nutrition in crops. *Agricultural Review*, **24**(3): 229-234.

Mahajan, H. S., Hirve, N. A. and Deshmukh, M. R. (2013). Effect of integrated nutrient management on seed yield and economics of sesame (*Sesamum indicum* L.) in assured rainfall zone of North Maharashtra. *Journal of Oilseeds Research*, **30**(2): 147-149.

Mahajan, H. S., Patil, Y. G., Hirwe, N. A., Patil, T. R. & Deshmukh, M. R. (2016). Effect of foliar nutrition of urea and diammonium phosphate on seed yield and economics of sesame (*Sesamum indicum* L.) under rainfed situation. *International Journal of Agricultural Sciences*. **12** (1): 101-105.

Malik, M. A., Saleem, M. F., Cheema, M. A. and Ahmed, S. (2003). Influence of different nitrogen levels on the productivity of sesame (*Sesamum indicum* L.) under varying planting patterns. *International Journal of Agriculture and Biology*, **5**(4): 490-492.

Mandeep, K. Santosh, K. and Amandeep, K. (2019). Effect of foliar application of nitrogen, phosphorus and sulphur on growth and yield of Gobhi Sarson (*Brassica napus* L.) in central Punjab. *Journal of Oilseed Brassica*, **10**(1): 47-50.

Mian, M. A.K., Uddin, M. K., Islam, M. R., Sultana, N. A. and Hosana, K. (2011). Crop performance and estimation of the effective level of phosphorus in sesame (*Sesamum indicum* L.). *Academic Journal of Plant Sciences*, **4**(1): 1-5.

Nandhini, P., Muthumanickam, D., Pazhanivelan, R. S., Kumaraperumal, R., Ragunath, K. P. and Sudarmanian, N.S. (2022). Inter comparision of drone and

conventional spraying nutrients on crop growth and yield in black Gram (*Vigna mungo*.L*). International Journal of Plant and Soil Science*, **34**(20): 845-852.

Ojikpong, T. O., Okpara, D. A. and Muoneke, C. O. (2009). Effect of time of introducing sesame and nitrogen, phosphorus, potassium fertilizer on sesame/soybean intercropping in the Southeastern rain forest belt of Nigeria. *Journal of Plant Nutrition*, **32**(3): 367–381.

Olsen, S.R. (1954). Estimation of available phosphorus in soil by extraction with sodium bi-carbonate. USDA Circular, **939**: 1-19.

Padasalagi, R. M., Lalitha, B. S. and Raddy, G. (2024). Nutrient uptake and quality of sesame (*Sesamum indicum* L.) as influenced by sulphur and boron. *International Journal of Environment and Climate Change* **14**(3): 405-418.

Panse, V. G. and Sukhatme, P. V. (1985). Statistical Methods for Agricultural Workers. *Indian Council of Agricultural Research*, New Delhi.

Patel, H. A. and Raj, A. D. (2017). Nutrient content as well as uptake of summer sesame as affected by nitrogen, phosphorous and biofertilizer under South Gujarat condition. *International Journal of Chemical Studies*, **5**(6): 1-4.

Patel, S. G., Leva, R. L., Patel, H. R. and Chaudhari, N. N. (2018). Effect of spacing and nutrient management on summer sesame (*Sesamum indicum* L.) under south Gujarat conditions. *Indian Journal of Agricultural Sciences*, **88**(4): 128-131.

Pathak, H., Kumar, G., Mohapatra, S., Gaikwad, B. and Rane, J. (2020). Use of drones in agriculture: Potentials, problems and policy needs. ICAR-National Institute of Abiotic Stress Management, pp.1-19.

Prakash, M. S., Saravanan, K. R., Kumar, B. S., Jagadeesan, S. and Ganesan, J. (2013). Effect of plant growth regulators and micronutrients on yield attributes of sesame. Sesame/Safflower Newsletter, pp. 18.

Pravalika, K., & Dawson, J. (2023). Effect of basal application of sulphur and foliar application of micro-nutrients on growth and yield of summer sesame. *International Journal of Environment and Climate Change*, **13**(5), 11-16.

Priya, H. K., Ramesh, K., Deep Tuti, M., Anjaiah, T., Qureshi, A., and Yadav, P. (2022). Effect of tillage and nutrient management practices on growth, yield and oil quality of rice fallow sesame. *International Journal of Environment and Climate Change*. **12**(11): 1921-1929.

Ramesh, K. and Thirumurugan, V. (2001). Effect of seed pelleting and foliar nutrition on growth of soybean. *Madras Agricultural Journal*, **88**(7): 465-468.

Ruchitha, P., Umesha, C. and Ashok, G. (2023). Response of sulfur and zinc on growth and yield of sesame (*Sesamum indicum* L.). *Environment and Ecology*, **10**:1674-1679.

Sahu, G., Bhuyan, B., Mishra, S., Panda, D., and Bebarta, A.A. (2024). Effect of irrigation and nutrient management studies on sesame (*Sesamum indicum* L.*). International Journal of Plant and Soil Science*, **36**(2): 81-95.

Samui, S., Sagar, L., Sankar, T., Manohar, A., Adhikary, R., Maitra, S. and Praharaj, S. (2022). Growth and productivity of rabi maize as influenced by foliar application of urea and nano-urea. *Crop Research*, **57**(3): 136-140.

Sangma, D. M., Longkumer, L. T., Singh, A. P. and Solo, V. (2022). Effect of planting density and integrated nutrient management in sesame (*Sesamum indicum* L.). *Agricultural Science Digest-A Research Journal*, **42**(1), 26-31.

Seervi, D., Choyal, P. and Seervi, K. S. (2018). The effect of micronutrients applied as foliar spray, on yield and yield attributes and oil content of sesame crop (*Sesamum indicum* L.). *Journal of Pharmacognosy and Phytochemistry*, **7**(4): 1402-1404.

Shweta, K., A., Kavita, and Nagora, M. (2023). Response of sesame to varied nitrogen and phosphorus levels under irrigated conditions. *Biological Forum an international journal*, **15**(6): 381-384.

Shwetha, B. N., Anupama, C., Sowmya, T. M. and Raghavendra, Y. (2018). Effect of foliar nutrition on productivity of groundnut crop. *Journal of Pharmacognosy and Phytochemistry*, SPI: 2357-2360.

Sonawane, B. B., Nawalkar, P. S. and Patil, V. D. (2010). Effect of micronutrients on growth and yield of groundnut. *Journal of Soils Crops*, **20**(2): 269-273.

Subbiah, B. V. and Asija, G.L. (1956). A rapid procedure for the determination of available nitrogen in soils. *Current Science*, **25**(8): 259-260.

Swain, B. C., Mishra, S. P., Dash, S. and Padhiary, A. K. (2020). Effect of foliar application of nutrients on growth and yield of sesame (*Sesamum indicum* L.). *International Journal of Conservation Science*, **8**(4): 1890-1895.

Teresa, A., Srinivasan, K. and Murali Arthanari, P. (2017). Effect of seed pelleting and foliar nutrition on growth and yield of summer irrigated sesame (*Sesamum indicum* L.). *Madras Agricultural Journal*, **104**(10-12): 350-353.

Thanki, R. B., Solanki, R. M., Modhavadia, J. M., Gohil, B. S. and Prajapati, P. J. (2014). Effect of irrigation scheduling at critical growth stages and fertility

levels on growth, yield and quality of summer sesame (*Sesamum indicum* L.). *Journal of Oilseed Research*, **31**(1): 41-45.

Tripathy, S. and Bastia, D. K. (2012). Irrigation and nutrient management for yield augmentation of summer sesame (*Sesamum indicum* L.). *Journal of Crop and Weed*, **8**(2): 53-57.

Vaghani, J. J., Polara, K. B., Chovatia, P. K., Thumar, B. V. and Parmar, K. B. (2010). Effect of nitrogen, potassium and sulphur on their content and uptake by sesame. *An Asian Journal of Soil Science*, **5**(2): 356-358.

Veeramani, P., Subrahmaniyan, K. and Ganesaraja, V. (2012). Nutrient management for sustainable groundnut productivity in India -a review. *International Journal of Engineering Science*. **11**(3): 8138-8153.

Verma, S., Saxena, R. and Singh, H. V. (2012). Integrated nutrient management in sesame (*Sesamum indicum* L.). *Bioinfolet*, **9** (4): 576-579.

Vinod, H. M. and Salakinkop, S. R. (2017). Growth analysis in groundnut (*Arachis hypogea* L.) as influenced by foliar nutrition. *Legume Research*, **40**(6): 1072-1077.

Signature of Student **Signature of Major Guide**

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